【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Mathematics/Physics)

Title of Project: Innovation of the "interstellar medium" by accurate measurements of the interstellar hydrogen

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Research Area : Astronomy
Keyword : Interstellar Hydrogen, Interstellar Dust, Gamma-rays, Baryon, NANTEN2

【Purpose and Background of the Research】

It is one of the most fundamental issues in astronomy to understand the behavior of hydrogen in the interstellar medium (ISM), because hydrogen is the most abundant element in the Universe. Neutral atomic hydrogen HI is the most abundant in the interstellar space and it reacts with each other on dust surfaces to form molecular hydrogen H_2. In order to better understand the ISM and its evolution in galaxies, we should have precise measurements of the hydrogen mass and its physical properties including density and temperature. Generally, 21 cm HI emission is assumed to be optically thin and the HI column density N_{HI} is calculated under the assumption. Recent two papers, Fukui et al. (2014, 2015), present a new analysis of HI and the Planck dust optical depth and concluded that the HI emission is often optically thick with an average optical depth of around 2 in the local space within a few 100 pc of the sun. This implies that the N_{HI} in the interstellar space is to be doubled due to the opacity correction as compared with the classical optically thin approximation, and, in addition, leads to a conclusion that the optically thin HI is identified in the warmest dust temperature.

The research has a potential to alter significantly a number of important issues on the ISM; they include the accurate density distribution of the interstellar clouds both in HI and H_2, the observational identification of conversion of HI into H_2, the origin of gamma rays and cosmic ray density, and the star formation history of galaxies over 10 Byrs [star formation rate is given as a ratio of the stellar mass and the hydrogen mass.

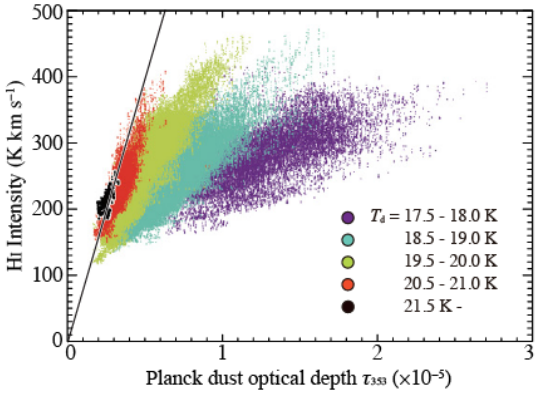

Fig.1 Scatter plots of the dust optical depths and HI intensity for the dust temperature in window of 0.5 K intervals every 1 K.

【Research Methods】

The proposed research aims at obtaining the best view of the interstellar hydrogen by new large scale observations of CO and HI combined with extremely high angular resolution observations for selected regions.

The new CO observations with NANTEN2 will cover 40 % of the sky with the 4-beam (dual polarization) array receiver, where Planck 353 GHz dust opacity is greater than $\sim 5\times10^{-6}$ well beyond the CO detection limit. The HI data will be taken in the GASKAP project at typically 20–60 arcsec resolution. The lower-resolution large-scale studies of CO and HI planned on NANTEN2 (CO) and GASKAP (HI) will be followed up by higher resolution studies with ALMA both in CO and dust continuum emission.

【Expected Research Achievements and Scientific Significance】

The expected outputs of the proposed research include accurate projected distribution of all hydrogen in nearby interstellar cloud with unprecedented accuracy in the order of 10 % as compared with the typical accuracy of a factor of two. Since the derived N_{HI} will be significantly larger by a factor of 2–5 than that estimated by the optically thin approximation, the resultant density distribution should be significantly different and denser in the transition layer of HI–H_2. This naturally requires new exploration of the cloud structure of physical evolution which leads to star formation and has a significant impact on our understanding clouds and star formation therein.

【Publications Relevant to the Project】

"HI, CO, and Planck/IRAS Dust Properties in the High Latitude Cloud Complex, MBM 53, 54, 55 and HLCG 92-35. Possible Evidence for an Optically Thick HI Envelope around the CO Clouds", Fukui, Y., Yamamoto, H., Tachihara, K. et al. ApJ, 796, 59–69, 2014

"Optically Thick HI Dominant in the Local Interstellar Medium: An Alternative Interpretation to "Dark Gas"", Fukui, Y., Yamamoto, H., Tachihara, K., Sano, H. et al. ApJ, 798, 6–20, 2015

【Term of Project】 FY2015-2019

【Budget Allocation】 424,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.a.phys.nagoya-u.ac.jp/nanten/en/